

Appendix B

Rehabilitation of Pump Stations and Well Heads: Electrical Systems and Monitoring and Control Systems

B.1 Introduction

Field visits and meetings with NGWA personnel have been conducted to identify the requirements and costs for rehabilitation of pump stations and wells, with respect to electrical systems and monitoring and control systems. The investigations covered 13 pump stations and 54 wells. The information collected on the status of equipment at each site included the following:

- Pump characteristics
- Low voltage panels, including the following components:
 - Main breakers
 - Branch breakers
 - Bus bars
 - IP of the enclosure
 - Safety
 - Mounting plate
 - Panel openings
 - Cable termination and installation inside the panel
- High voltage switch gear
- Power cables
- Cable trenches

The pump stations evaluated in this investigation included the following: Tabaqat Fahel; the four Wadi Al-Arab pump stations PS0, PS1, PS2 and PS3; Zubdat reservoir and pump station; Hofa; Samad; Al Hoson; Al-Za'tary; Um El-Lulu; Al-Boaida; and Khaldiye. The groundwater wells evaluated are listed below:

Well ID	Description	Well ID	Description
F 1310	Al' Aqeb Well K114	AL3452	Al' Aqeb Well K091.5
F 1312	Al' Aqeb Well K112	AL1558	Al' Aqeb Well K090
F 1079	Al' Aqeb Well K111(B)	AL1491	Rawdah Ameer Basma Well
F 3930	Al' Aqeb Well K111(A)	AL3563	Um AL Jemal Well 3
F 1333	Al' Aqeb Well K110	AL2710	AL Za'tary Well 3
F 1389	Al' Aqeb Well K109	AL3002	AL Za'tary Well 4
AL2689	Al' Aqeb Well K107	AL3003	AL Za'tary Well 5
AL3517	Al' Aqeb Well K106 (B)	AL3463	AL Za'tary Well 6
AL1274	Al' Aqeb Well K106 (A)	AL3375	AL Za'tary Well 7
AL1225	Al' Aqeb Well K104	AL3376	AL Za'tary Well 9
AL3518	Al' Aqeb Well K103 (2)	AL3377	AL Za'tary Well 10
AL1495	Al' Aqeb Well K103 (1)	AE1010	Wadi Al Arab Well 4
AL1273	Al' Aqeb Well K102.5	AE1009	Wadi Al Arab Well 3
AL3422	AL Zamlah Well (Zamlehet Al Ameer Gazi)	AE1008	Wadi Al Arab Well 2
AL1265	Al' Aqeb Well K102	AE1007	Wadi Al Arab Well 1
AL3513	Al' Aqeb Well K101(A)	AE1011	Wadi El Arab Well 5
AL3681	Al' Aqeb Well K101(B)	AE1012	Wadi El Arab Well 7
AL1193	Al' Aqeb Well K 96(2)	AB1355	Al Manshyeh PS 2
AL3362	Al' Aqeb Well K 96(1)	AB3003	Al Manshyeh PS 1
AL1241	Al' Aqeb Well K095	AB1375	Juhfiyya PS Well 1
AL3004	Al' Aqeb Well K094.5	AB1441	Juhfiyya PS Well 1A
AL1486	Al' Aqeb Well K094	AL1490	Um AL Jemal Well 1
AL3423	Al' Aqeb Well K093.5	AE1004	Al-Elbait University
AL1485	Al' Aqeb Well K093	AL1023	Khaldyeh PS Well 17

B.2 Evaluation of Electrical Installations at Pump Stations

The findings and observations from field visits and meetings with NGWA staff, concerning the status of the electrical installations at pump stations, are described below.

The rehabilitation requirements are very similar at many of the pump stations. In presenting the conclusions of the evaluation, to prevent un-necessary repetition, it should be understood that wherever it is recommended to replace an item, it is because the existing item is either in very bad condition, very old, not functioning efficiently, or requires excessive or frequent maintenance.

B.2.1 Tabaqat Fahel Pump Station

Tabaqat Fahel pump station consists of the following:

- 100kW motor control center
- 60kW motor control center
- 400A main breaker

The following conclusions were reached:

- Main breaker with enclosure has to be replaced.
- 100kW MCC has to be replaced.
- 60kW MCC enclosure to be painted and the cables inside the panel to be re-installed properly.
- All cables feeding the pumps to be re-installed and placed properly in trenches.
- No capacitor banks were found.
- No PLCs (programmable logic controllers) exist; the pumps are controlled manually, and not connected to any control and monitoring system; as a result, no remote monitoring is available.

B.2.2 Wadi Al-Arab Pump Station PS0

Wadi Al-Arab Pump Station "PS0" is newly reconstructed and consists of the following:

- 5 pumps 6.6KV, 900kW each, 3 pumps-duty, and 2 pumps -standby.

The following conclusions were reached:

- High voltage switchgear is new, working well, and in excellent condition.
- Low voltage panels and capacitor banks are new, working well, and in excellent condition.
- All cables and cable terminations are installed in compliance with good engineering practice.
- Maintenance follow-up appears acceptable.
- The pump station is newly constructed.
- A PLC system has been installed, but has the following shortcomings:
 - The SCADA system in the station is not working; the monitoring is carried out via field panels.
 - Communications has been interrupted by damage to the telemetry cable, and hence remote monitoring and control are not available.

B.2.3 Wadi Al-Arab Pump Stations PS1, PS2, and PS3

Each of the three Wadi A-Arab pump stations designated as PS1, PS2, and PS3 consists of the following:

- 4 old 6.6KV pumps (19 years old).
- 3 new 6.6KV pumps.

The following conclusions were reached:

- High voltage switchgear is working well and in good condition.
- Low voltage panels and capacitor banks are working well and in good condition.
- All cables and cable terminators are installed in compliance with good engineering practice.
- Maintenance follow-up has been very satisfactory to date.
- A PLC system has been installed but has the following shortcomings:
 - Old models of control devices are installed on the old pumps. New PLCs and RTUs should be installed on the old pumps and connected into the old control and monitoring system.
 - An old SCADA system in these stations is not working properly, and all components are outmoded.
 - A new SCADA system has been installed but is not yet operational.
 - Communications has been interrupted by damage to the telemetry cable. Remote monitoring and control is not available. A new telemetry cable or GSM communication system should be installed.

B.2.4 Zubdat Pump Station

Zubdat pump station consists of the following:

- 5 existing pumps with the following loads: 320kW, 320kW, 290kW, 420kW, 400kW.

The following conclusions were reached:

- All of the 5 panels for the pumps must be replaced.
- Capacitor banks must be added to the station.
- Cable terminations must be rehabilitated.
- Some of the cable boxes on the pumps were open. Covers are required.
- The pump station contains the remote monitoring and control system for the old Wadi Al-Arab Pump Stations PS1, PS2, and PS3. The flow of some pumps is being monitored, but there is no remote control of the pumps available. The system is not working properly and is outmoded.
- A new monitoring system for the newly-installed pumps is not working at all.
- No PLCs were found for the Zubdat pump station.
- A full monitoring and control system should be installed, encompassing the pumps in Zubdat and the nearby old pumps as well.

B.2.5 Hofa Pump Station

Hofa pump station consists of the following:

- 3 pumps with the following loads: 440kW, 320kW, 172.5kW.

The following conclusions were reached:

- The control panels for Pumps 1 & 2 are very old and must be replaced.
- The electrical enclosure for Pump 3 must be replaced.
- The main panel must be replaced, but the main breaker from the old panel can be retained in the new panel.
- Power cable terminations must be rehabilitated.
- Some cable boxes on the pumps are open; new box covers are needed.

- Monitoring and control is carried out manually. RTU and PLCs are required.

B.2.6 Samad Pump Station

Samad pump station consists of the following:

- 4 pumps with the following loads: 200kW, 200kW, 550kW, 230kW.

The following conclusions were reached:

- Power panels 1, 2, 3 and 4 must be replaced.
- New cables must be installed.
- Cable trenches must be provided.
- Cable terminations must be rehabilitated.
- PLCs and remote monitoring are needed in place of manual monitoring and control.

B.2.7 Huson Pump Station

Al Hoson pump station contains the following:

- Three power panels with the following loads: 220kW, 110kW, 132kW.

The following conclusions were reached:

- Power panels 1, 2 & 3 must be replaced.
- New cables must be installed.
- Cable trenches must be provided.
- Cable terminations must be rehabilitated.
- Manual monitoring and control should be replaced by PLCs and a remote monitoring and control system.

B.2.8 Al-Za'tary Pump Station

Al-Za'tary Pump Station consists of 12 pumps as follows:

- Pump 1 150 kW
- Pump 2 500 kW
- Pump 3 500 kW
- Pump 4 380 kW
- Pump 5 380 kW
- Pump 6 500 kW
- Pump 7 500 kW
- Pump 8 500 kW
- Pump 9 496.8 kW
- Pump 10 500 kW
- Pump 11 500 kW
- Pump 12 496.8 kW

The following conclusions were reached:

- Only 6 pumps are in use; the remaining 6 pumps are on standby and not needed.
- Extension and rehabilitation of the cable trenches are required.
- The 550kW Power panel needs repair (enclosure, cable fixing & termination).
- Periodic maintenance is required; the panels are very old.
- There is no remote monitoring /control system, aside from flow monitoring by GSM modem. Control is manual, without any PLCs or RTU.

B.2.9 Um El-Lulu Pump Station

Um El-Lulu pump station consists of the following:

- 4 pumps with the following loads: 440kW, 250kW, 500kW, 184kW.

The following conclusions were reached:

- The power panels are very old, and need replacement.
- Cable terminations need rehabilitation.
- No PLCs for pump control exist; control and monitoring is carried out manually. Flow is monitored remotely by GSM modem.

B.2.10 Al Bwaydah Algarbeyeh Pump Station

Al-Bwaydah pump station consists of the following:

- 3 pumps with the following loads: 90kW, 95.4kW, 90kW.

The following conclusions were reached:

- All panels are in very bad condition, and must be replaced.
- New cables must be installed.
- Cable trenches must be provided.
- Manual monitoring and control should be replaced by an automated system.

B.2.11 Khaldiye Pump Station

Khaldiye pump station consists of the following:

- 5 pumps with the following panels' loads: 300kW, 250kW, 200kW, 150kW & 175kW

The following conclusions were reached:

- Replacement of Power Panels 1 and 4 is needed.
- Power cable boxes are open; covers are needed.
- No cable glands are installed.
- The pump station is monitored and controlled manually; an automated system is needed.

B.3 Electrical Installations at Wells

For the many wells covered in this evaluation, the required improvements have been summarized and included directly in the cost estimate for rehabilitation. The types of improvements required are defined as follows:

- New panel: existing panels must be replaced.
- Enclosure maintenance: includes painting of the enclosure, replacement of the mounting plate, maintenance of the doors, etc.
- Panel accessories: replacement of indicator lights, selector switches, breakers, contactors, etc.
- Cable installation: cables need to be installed in trenches, and repairs made to cables, cable glands, accessories, etc.
- Cable trench repair: the cable trench should be covered and maintained.
- Cable trench excavation: new trenches for the cables should be built.
- Instrumentation: remote control and monitoring is needed.

B.4 Instrumentation, Monitoring & Control System

The existing monitoring and instrumentation system is very limited, consisting of the equipment installed in the Wadi Al-Arab pump stations. The old Wadi Al-Arab pumps and flow are monitored at the Zubdat pump station using an old and outmoded system. Control is carried out locally in each pump station and no remote controls are available. The new Wadi Al-Arab pumps are monitored by a new control and monitoring system which is not yet operational. Both of the Wadi Al-Arab systems (old & new) are not working properly because the telemetry cable has failed.

Flow in two pump stations in the East transmission system are monitored remotely through GSM modem and cellular telephone communications.

No remote monitoring of pumps in the pump stations, or of flow from the wells, is available.

We recommend the installation of new PLC and RTU units in all pump stations and wells, including the old Wadi Al-Arab pumps. A new SCADA system should be installed, with data communications provided either by fiber optical telemetry cable or GSM modem. The initial cost of installing a fiber optical telemetry cable is high, while the running cost is very low. On the other hand, the initial cost of using GSM modems is less than telemetry cable, but the running cost for cellular telephones is high. Given the flexibility and reliability provided by cellular phones, as evidenced by the damaged telemetry cable that has never been repaired, preference is given to the GSM modem/cellular phone option.

B.5 Estimated Cost for Rehabilitation of Electrical/Instrumentation Systems

Based upon an evaluation of the needs at each pump station and well, a cost estimate has been prepared, as shown below in **Table B-1**.

Table B-1 Summary of Electrical/Instrumentation Rehabilitation Requirements and Estimated Costs

Site	Rating	New Panel	Enclosure maintenance	New Capacitor Bank	Panel accessories	Cable Installation	New Cable	Cable Trench repair	Cable Trench excavation	Instrumentation integration, rehabilitation and activation	Instrumentation	Cost Estimate, Power (US\$)	Cost Estimate, Instrumentation (US\$)	Cost Estimate, Total (US\$)
Tabaqat Fahel pump station	100 KW											21,000	22,000	67,000
	60 KW											11,000		
	400A main											13,000		
Wadi Al-Arab pump station PS0, 6.6KV	900 KW												5,000	5,000
	900 KW													
	900 KW													
	900 KW													
	900 KW													
Wadi Al-Arab pump station (PS1)	-												35,000	35,000
	-													
	-													
	-													
	560 KW													
	560 kW													
	560 KW													
Wadi Al-Arab pump station (PS2)	-												35,000	35,000
	-													
	-													
	-													
	560 KW													
	560 kW													
	560 KW													

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Wadi Al-Arab pump station (PS3)	-												35,000	35,000
	-													
	-													
	-													
	560 KW													
	560 kW													
	560 KW													
Zubdah pump station	320 KW											33,000	35,000+ 50,000 for central control station	250,000
	320 KW											33,000		
	290 KW											33,000		
	420 KW											33,000		
	400 KW											33,000		
Hofa pump station	440 KW											30,000	25,000	145,000
	320 KW											30,000		
	172.5 KW											30,000		
	main											30,000		
Samad pump station	200 KW											23,000	25,000	132,000
	200 KW											23,000		
	550 KW											38,000		
	230 KW											23,000		
Al Hoson pump station	220 KW											23,000	25,000	94,000
	110 KW											23,000		
	132 KW											23,000		

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Al-Za'tary pump station	150 KW											5,000	60,000	128,000
	500 KW											13,000		
	500 KW											5,000		
	380 KW											5,000		
	380 KW											5,000		
	500 KW											5,000		
	500 KW											5,000		
	500 KW											5,000		
	496.8 KW											5,000		
	500 KW											5,000		
	500 KW											5,000		
	496.8 KW											5,000		
Um El-Lulu pump station	440 KW											33,000	25,000	127,000
	250 KW											18,000		
	500 KW											33,000		
	184 KW											18,000		
Al-Boaida pump station	90 KW											18,000	25,000	79,000
	95.4 KW											18,000		
	Un-known											18,000		
KhaldiyeH pump station	300 KW											33,000	25,000	130,000
	250 KW											18,000		
	200 KW											18,000		
	150 KW											18,000		
	175 KW											18,000		

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Site	Rating	New Panel	Enclosure maintenance	New Capacitor Bank	Panel accessories	Cable Installation	New Cable	Cable Trench repair	Cable Trench excavation	Instrumentation integration, rehabilitation and activation	Instrumentation	Cost Estimate, Power (US\$)	Cost Estimate, Instrumentation (US\$)	Cost Estimate, Total (US\$)
Al' Aqeb Well K114	132											10,000	12,000	22,000
Al' Aqeb Well K112	140											10,000	12,000	22,000
Al' Aqeb Well K111(B)	132											10,000	12,000	22,000
Al' Aqeb Well K111(A)	132											10,000	12,000	22,000
Al' Aqeb Well K110	129											10,000	12,000	22,000
Al' Aqeb Well K109	185											10,000	12,000	22,000
Al' Aqeb Well K107	92											10,000	12,000	22,000
Al' Aqeb Well K106 (B)	100											10,000	12,000	22,000
Al' Aqeb Well K106 (A)	100											10,000	12,000	22,000
Al' Aqeb Well K104	110											10,000	12,000	22,000
Al' Aqeb Well K103 (2)	132											10,000	12,000	22,000
Al' Aqeb Well K103 (1)	132											10,000	12,000	22,000
Al' Aqeb Well K102.5	132											10,000	12,000	22,000
AL Zamlah Well (Zamlehet Al Ameer Gazi)	75											10,000	12,000	22,000
Al' Aqeb Well K102	170											10,000	12,000	22,000
Al' Aqeb Well K101(A)	75											10,000	12,000	22,000
Al' Aqeb Well K101(B)	162											10,000	12,000	22,000
Al' Aqeb Well K 96(2)	173											10,000	12,000	22,000
Al' Aqeb Well K 96(1)	66											10,000	12,000	22,000
Al' Aqeb Well K095	132											10,000	12,000	22,000
Al' Aqeb Well K094.5	174											10,000	12,000	22,000
Al' Aqeb Well K094	100											10,000	12,000	22,000
Al' Aqeb Well K093.5	75											10,000	12,000	22,000

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Al' Aqeb Well K093	132											10,000	12,000	22,000
Al' Aqeb Well K091.5	95.5											10,000	12,000	22,000
Al' Aqeb Well K090	92											10,000	12,000	22,000
Rawdah Ameera Basma Well	92											10,000	12,000	22,000
Um AL Jemal Well 3	60											10,000	12,000	22,000
AL Za'tary Well 3	75											10,000	12,000	22,000
AL Za'tary Well 4	92											10,000	12,000	22,000
AL Za'tary Well 5	66											10,000	12,000	22,000
AL Za'tary Well 6	66											10,000	12,000	22,000
AL Za'tary Well 7	66											10,000	12,000	22,000
AL Za'tary Well 9	92											10,000	12,000	22,000
AL Za'tary Well 10	92											10,000	12,000	22,000
Tabaqat Fahel PS & Well 3												10,000	12,000	22,000
Tabaqat Fahel PS & Well 8	45											10,000	12,000	22,000
Tabaqat Fahel PS & Well 6	60											10,000	12,000	22,000
Tabaqat Fahel PS & Well 1	50											10,000	12,000	22,000
Tabaqat Fahel PS & Well 9 (Shboul Spring)												10,000	12,000	22,000
Wadi Al Arab Well 4	250											10,000	12,000	22,000
Wadi Al Arab Well 3	300											10,000	12,000	22,000
Wadi Al Arab Well 2												10,000	12,000	22,000
Wadi Al Arab Well 1	250											10,000	12,000	22,000
Wadi El Arab Well 5	200											10,000	12,000	22,000
Wadi El Arab Well 7	90											10,000	12,000	22,000

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Site	Rating	New Panel	Enclosure maintenance	New Capacitor Bank	Panel accessories	Cable Installation	New Cable	Cable Trench repair	Cable Trench excavation	Instrumentation integration, rehabilitation and activation	Instrumentation	Cost Estimate, Power (US\$)	Cost Estimate, Instrumentation (US\$)	Cost Estimate, Total (US\$)
Juhfiyya Pumping Station Well 1												10,000	12,000	22,000
Juhfiyya Pumping Station Well 1A												10,000	12,000	22,000
Um AL Jemal Well 1	66											10,000	12,000	22,000
Al-Elbait University												10,000	12,000	22,000
GRAND TOTAL												1,335,000	942,000	2,362,000